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NASA Communications (Nascom) Internet Protocol (IP) Transition Operations Concepts Document

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Greenbelt, Maryland

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Submitted by:	**Approved by:**
G. Gonzales Date Wide Area Networks Section Manager, CSC	S. Douglas IP Transition Project Engineer GSFC, Code 541.2
	B. Torrain, Branch Head Nascom Engineering Branch GSFC, Code 541
	Tom Butler, Chief NASA Communications Division GSFC, Code 540

Goddard Space Flight Center
Greenbelt, Maryland

Preface

This document is under the configuration management of the NASA Communications (Nascom) Configuration Control Board (CCB).

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Head, Systems Engineering Branch
Code 541
Goddard Space Flight Center
Greenbelt, Maryland 20771

Abstract

This Operations Concepts document describes the operational concepts of the Nascom IP networks for providing services for 4800-bit-block low speed data transport with an IP backbone.

Keywords: *Internet Protocol (IP), Conversion Device (CD), Nascom Interface Board (NIB), 4800-bit-blocks, TCP/IP, UDP/IP, NASA Communications (Nascom).*

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DCN Control Sheet

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1. Introduction

1.1 Purpose

This document describes the operations concepts for the Nascom IP Transition Project. Nascom is currently transitioning their 4800-bit-block point-to-point network to an IP backbone. This document describes the capabilities and services of the current network and traces how these capabilities and services will be provided within the target IP network architecture and management system. It also addresses operational concepts specific to the interim period as Nascom customers transition from the current network to IONET.

The scope of the initial transition is limited to 4800-bit-block message switching services for the Ground Network (GN) and some low speed circuit switching services for the Space Network (SN).

1.2 Background

The goal of the IP transition is to reduce the cost of Nascom Network operation by reducing the use of custom hardware and software and reducing the number of personnel required to maintain and operate the Network. The objective is to replace the current 4800-bit-block point-to-point serial Nascom network infrastructure and supporting Domestic Satellite with an IP-based infrastructure without disrupting current data flows.

Existing 4800 bit-block services will be provided by encapsulating 4800 bit-blocks in UDP/IP datagrams using Nascom provided conversion devices. Modified Multiplexers/Demultiplexers(MDMs) will be used at White Sands Complex (WSC) and Johnson Space Center (JSC) to convert data to and from the IP infrastructure. Conversion Devices will be added at user destinations to convert UDP/IP data packets back to serial 4800 block data for the user circuits and vice versa. The 4800 bit-block data will be encapsulated at the source, sent over an IP/UDP network and de-encapsulated back to serial data for the destination serial circuits. A Nascom Network Management System (NMS) will support user needs by providing special communication configuration capabilities and monitoring services.

1.3 Document Organization

This document is organized in four sections, as follows:

Section 1 describes the purpose, background, organization, and references of the document.

Section 2 describes the current network environment including architecture and basic modes of data transport.

Section 3 describes target network environment including architecture, data transport, and management.

Section 4 describes transition strategy.

1.4 References

The documents listed here are references. These documents can be used to further understand the Nascom IP transition operations concepts.

1. NASA, 541-231, *NASA Communications (Nascom) Internet Protocol (IP) Transition Data Format Document*, June 1996.
2. NASA, 541-229, *Nascom IP Transition Project Transition Plan* , July 1996.
3. NASA, 542-006, *NASA Communications Operating Procedures (NASCOP)*, Volume 2, Revision 1, July 1990.
4. NASA, 540-030, FY96 *Nascom System Development Plan* Review Copy.
5. NASA, 542-016, *Nascom Space Network Ground Segment Support Data Book*, Rev 1, DCN 4, October 1995.
6. NASA, 541-232, *NASA Communications (Nascom) Small Conversion Device (SCD) Operator's Guide*, July 1996
7. NASA, 541-200, *NASA Communications (Nascom) Small Conversion Device (SCD) System Requirements*, (June 1996)
8. *The Nascom Systems Test Team Philosophy for Testing the Nascom IP Transition Project.*, July 1996
9. NASA, 542-002, *Digital Data Source/Destination and Format Codes Handbook for the Nascom Message Switcing System*, Rev 4, DCN1, May 1996.

2. Current Network Environment

This section provides an overview of the current Nascom network environment, modes of data transport, and operations involved initially in the transition to an IP backbone. The initial transition includes components of both the SN and GN Data Transport Systems. As of June, 1996 the wide area requirements included approximately 200 circuits to 26 locations outside of GSFC. The GSFC campus requirements include approximately 300 circuits at 20 locations.

2.1 Nascom Management and Operations Overview

The Nascom Network is a generic term referring collectively to the circuits, switching and terminal facilities established and operated by Nascom globally to provide operational telecommunications support for all NASA projects. All operational telecomunications between NASA locations and between NASA and cooperating terminal locations are under centralized management at the Goddard Space Flight Center (GSFC).

The Nascom Network interconnects NASA's domestic and foreign tracking and telemetry acquisition sites, launch areas, mission Project Operations Control Centers (POCC), science Data Capture Facilities (DCF), and network control centers.

The Communications Manager (COMMGR) is responsible for the overall technical and operational management of the Nascom Network. The Nascom Network control facilities at GSFC constitute the Nascom Primary Switching Center including three functional areas: Voice Control Section, Data Switching Section, and Technical Control Section. The Technical Control Section is the focal point for all data transport systems providing configuration and distribution of user data and testing and maintenance of circuitry and terminal equipment.

2.2 SN Data Transport Environment

The Nascom Network extends the Tracking and Data Relay Satellite System (TDRSS) forward-link command and return-link telemetry services by providing data transport systems between the WSC and major user spacecraft control centers and data-processing facilities. This support includes full-period data comunications services between GSFC, WSC, and Johnson Space Center (JSC) that have been leased from Domestic Satellite (DOMSAT) common carriers. Nascom provides service entry points to the data transport systems at the GSFC, MSFC and JSC locations for all SN users. The data transport systems provide the users individual access interfaces for command and telemetry via digital matrix switching systems. This allows users to have discrete channel interfaces with Nascom for command and telemetry to and from their spacecraft on a scheduled, time-shared basis.

The transport system that provides for the ground system extension of the TDRSS services in the low- to mid-rate ranges is referred to as the Baseline Data System (BDS). The BDS includes the broadcast system and a Multiplexer/Demultiplexer (MDM) system. The WSC MDM systems are primary interfaces with the TDRSS. The MDM systems at GSFC, MSFC, and JSC are primary interfaces to the spacecraft project users. Redundant MDM systems are uplinked through two separate satellites to GSFC, JSC, and WSC to form a Broadcast System (prime and alternate). A single point-to-point system exists between GSFC and MSFC and has no redundancy. The BDS is illustrated in Figure 2.1.

The Logical Port Addresses (LPAs) on the MDM systems are defined by Nascom and documented in the *Nascom SN Ground Segment Support Segment Data Book, 542-016.*

The source/destination codes used to route traffic through the BDS are defined by Nascom and documented in the *Digital Data Source/Destination and Format Codes Handbook for the Nascom Message Switching System, 542-002.*

The Network Control Center (NCC) provides scheduling information to Nascom's Control and Status System (CSS) for automated configuration of the circuits as needed to support Space Network (SN) circuit switching services. The backbone communication is provided by the DOMSAT. The common carrier interfaces (CCI) lead into patch panel interfaces to the MDM Systems. In addition the GSFC switching hardware includes a Digital Matrix Switch (DMS) to the users.

2.3 GN Data Transport

Nascom's MSS is used to switch and route real-time 4800-bit-block data including telemetry/command, tracking, acquisition, scheduling, and scientific data between users within NASA's global GN communication network. MSS provides table-driven fully automatic, real-time, block-by-block switching and distribution on serial lines. Data message switching is the function of receiving a serial stream of contiguous or non-contiguous data blocks from one or more input data channels and automatically routing and distributing each data block (based on destination code contained within each) to the appropriate output data channels. No end-of-message sequence is required. Knowledge of 4800-bit-block length and synchronization codes are used to detect new blocks.

In addition to the routing function, the MSS performs the following functions:

1. Block multiplexing/demultiplexing on data channels
2. Multi-addressing for messages requiring multiple destinations
3. Channel speed-matching

The MSS switches data to and from low to mid data rate network control and processing facilities and local/remote POCCs and their supporting networks. The functions supported include transmission of tracking data to and from Flight Dynamics Facility (FDF), forecast of scheduling services needs from POCCs to the NCC, operational messages between TDRSS and NCC and between NCC and SN users, and mission payload information for spacecraft control and user facilities.

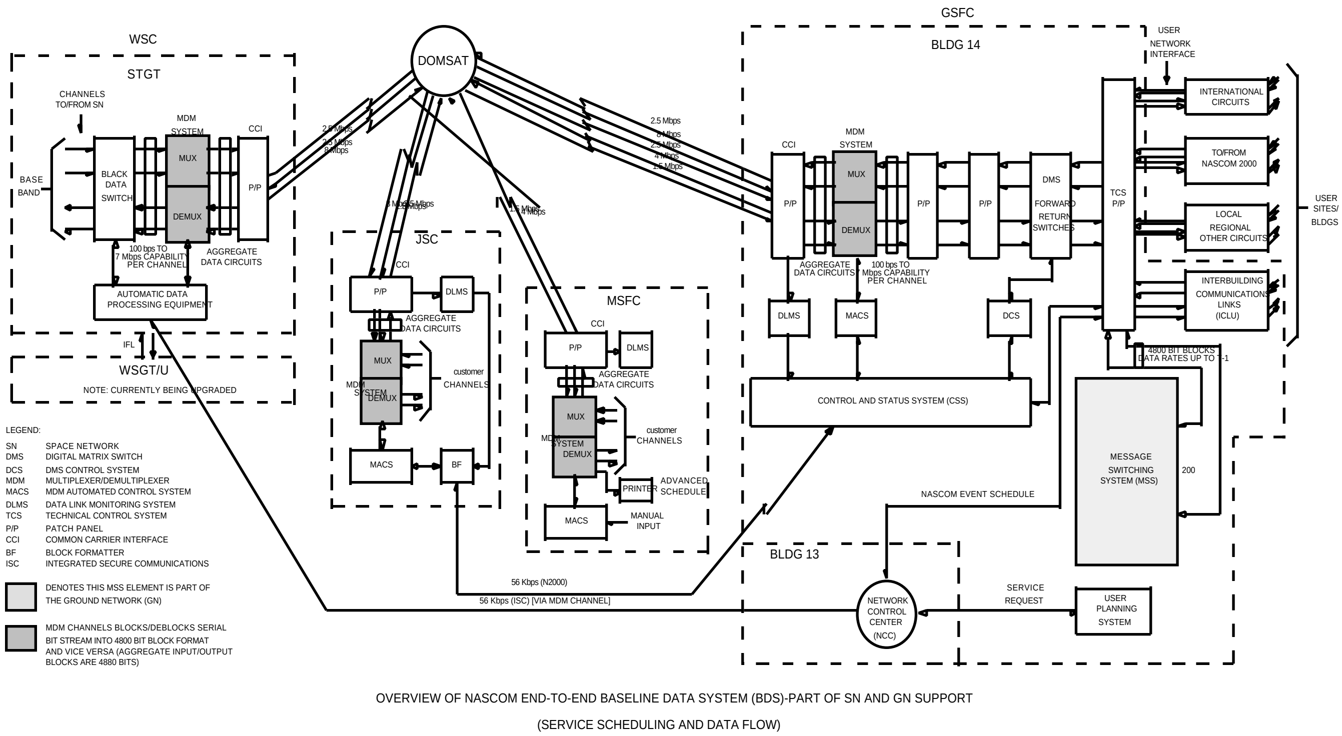


Figure 2.1 Baseline Data System

2.4 Circuit Switching

Circuit switching is the routine operational connecting of one circuit to another performed by Nascom in response to schedules or real-time requests. It may be accomplished in several ways depending on the circuits involved. It may be done manually, using the analog and digital high speed and wideband patch panels in Technical Control to accomplish the direct interconnection (hardware) of long-haul point-to-point and/or local GSFC data channels. It may be accomplished semi-automatically via the DMS local operator console or from the MACS or MDM Local Control and Monitor (LCM) console. Circuit switching may also be accomplished automatically under the scheduled control of the CSS. This definition distinguishes circuit switching operations from message switching and those switching functions performed for trouble isolation, circuit testing, and restoration.

SN circuit switching provides point-to-point and point-to-many data transport between TDRSS and users at WSC, GSFC, JSC, MSFC and other network users. **Return data service** refers to the return of spacecraft telemetry data from TDRSS to WSC for distribution to users via the BDS. **Forward data service** transports command data from user via to WSC and TDRSS for spacecraft.

2.4.1 MDM Data Transport

Integral to Nascom's circuit switching capabilities is the MDM data transport system.

Users schedule TDRSS services and associated MDM data transport services through the Network Control Center (NCC). These scheduled services comprise events where an event is a collection of up to 30 data streams, each with a duration of less than 24 hours. Each data stream is identified with a user spacecraft that uses network communication resources for a scheduled period of time. The schedule of events is transmitted to the CSS daily with real-time changes for ongoing data flows and updates to the daily schedule also sent to the CSS by the NCC. The CSS provides the automated configuration of the GSFC and JSC MACs and GSFC DCS systems to support scheduled services. The CSS also produces an Advance Schedule based on the schedule from the NCC. It is printed to use for manual configuration as a contingency in case the CSS or CSS circuits to JSC and GSFC MDMs and GSFC DMS are not available. The hard copy Advance Schedule is available to the COMMGR and JSC personnel.

The data system user can select data service options for each event via configuration codes; that is, pre-defined sets of TDRSS service and transport parameters. For example the MDM data system user can select blocked or unblocked data, data rate and whether to receive circuit assurance blocks (CABs). See pages 5-20 through 5-22 of NASCOP , Reference 3, for more details.

Scheduling network services via configuration codes also allows users to define multiple destinations for return service data from the TDRSS. Use of different configuration codes also allows different sets of destinations based on the user's needs. Thus data arriving at the same Logical Port Address (LPA) in a GSFC MDM may be routed to a different set of user destinations based on the GSFC scheduling and configuration information sent by the NCC to the CSS for configuring the DMS system which can distribute input data to up to eight output ports (e.g end users). In order to provide a smooth transition to IP, changes are being made to ensure a fixed destination code for each LPA.

Accountability for data is provided by user application programming using 4800-bit-block headers and protocols.

2.4.2 SN Playback Services

A playback service is the replay of TDRSS telemetry data previously recorded at WSC for return to the users either for recovery or tests. Playbacks are scheduled and typically coordinated by voice through the NCC. A POCC initiates a playback request to the NCC. NCC responds to an accepted playback request with a teletype schedule confirmation message to the POCC and Nascom and a General Administrative Message (GAM) to WSC. The GAM is entered into the WSC Automated Data Processing Equipment (ADPE) which displays the information required for retrieval, local configuration and event timeline. Verbal requests may be accepted from the NCC if they contain the same information as the NCC confirmation message and GAM. The NCC Performance Analyst (PA) coordinates playbacks on a voice coordination loop with WSC and the requesting POCC.

For a Type-I playback the COMMGR coordinates the playback. By 10 minutes prior to the playback event start time, the COMMGR confirms with WSC the playback channel to be used and advises Technical Control of the pertinent configuration information. Technical Control will confirm to the COMMGR that the playback interface has been extended to the user. The COMMGR advises the NCC PA that the playback is configured.

Normally, the user sends their request to the NCC, the NCC contacts the Nascom COMMGR, who contacts Technical Control, who contacts WSC. A schedule request is generated only about 20% of the time. Sometimes a schedule request is generated after the actual playback, as confirmation. The COMMGR does the verbal co-ordination of the playback. The user can configure playback on either the same or a different circuit than real-time. This is accomplished by using dedicated circuits in some cases and in some cases using a spare circuit and requiring a change to the Destination Code Mapping table. There are currently 2 ports available for playback at GSFC and 1 at JSC. Only HST and sometimes STS can receive playback and realtime data simultaneously.

2.5 Testing Services

Normal day-to-day operations are scheduled (including the use of the leased long-lines), but extensive human intervention is required for engineering tests. Human intervention is in the form of telephone coordination and circuit patching or configuration. There are usually 6 to 20 tests scheduled each day. Briefing notices are prepared by the NCC based on user information. The COMMGR uses the telephone to schedule the resources required for these tests, especially with the Simulation Operations Center (SOC) and other simulation centers such as Vehicle Electrical System Test (VEST) in Building 29 and Support and Maintenance Systems (SAMS) in Building 1 (SAMS is an HST backup system).

Most engineering tests are circuited switched at a patch panel or the DMS, rather than going through the MSS.

2.6 Emergency Services

The current network operation allows extensive flexibility to meet emergency situations in real-time using special patching and real-time changes to MSS destination codes.

2.7 ‘Making Good’ Services

Nascom provides Technical Control services to maintain the continuity and integrity of the data transport system of the Nascom Network. Technical Control personnel provide fault isolation, troubleshooting, and restoral of service ('making good' a bad connection) which includes extensive capability to patch around problems.

Operations uses the Performance Monitoring System (PMS) to pro-actively monitor the status of the network. They also monitor equipment alarms and receive problem reports from users. The formal error reporting procedure is that the user calls the NCC if they have a problem receiving data but generally most users contact the COMMGR first. If contacted, the NCC determines whether it is a Nascom or ground station problem, and forwards the report to Nascom if it isn't a ground station problem. About 70% of the problem reports that Nascom investigates turn out not to be a Nascom problem. Currently Nascom has the capability to troubleshoot problems outside their demarcation points in order to pinpoint problems and expedite return of service. If Nascom detects a total failure, they ‘make good’ the circuit and then inform the user. Nascom first contacts the user if it is a partial failure and lets the user determine whether to fix the problem.

2.8 Planned Changes

Future communication changes affecting Nascom are documented in Detailed Mission Requirements (DMRs) which list the type of data (data, voice, etc.) and data flows. Communication Service Requests (CSRs) are required for software or circuit changes, Engineering Changes (ECs) for hardware changes, and QA forms for testing. DMRs generally affect multiple locations. Nascom tests all new or changed services before they are turned over to the user.

More and more of the services being installed are dedicated, rather than shared. This is driven at least partly by full cost accounting, so that the circuit costs can be charged back to each project.

2.9 Full Period Services

Full period services typically refer to two types of data transport configurations: hard-wired and open DMS connections. The hard wired connections are typically MSS type circuits and involve the physical splitting of data onto multiple circuits. The full period DMS connections are described in the *NASA Communications Space Network Ground Segment Support Data Book* in Section 4. They include almost 20 types of data and remain open all the time.

3.0 Target Network Environment

This section describes the target IP Architecture, basic data transport modes, and operational scenarios.

3.1 IP Architecture

3.1.1 IP Operational Network (IONET)

The target IP Operational Network will be an expansion of the closed segment of the current IONET which includes MODNET (MO&DSD Operational/Development Network) and NOLAN (Nascom Operational LAN). The IONET is based on the existing five year-old Nascom IP network called MODNET/NOLAN--a routed network with WAN extensions to remote locations. It has 24 hour a day, 7 day-a-week maintenance and operations support and has had 100% availability on the FDDI backbone since inception. Figure 3.1 provides a high level view of the open FDDI segment, the closed FDDI segment, the secure gateway protecting the closed segment, and the target Nascom IP network expansion to the closed segment.

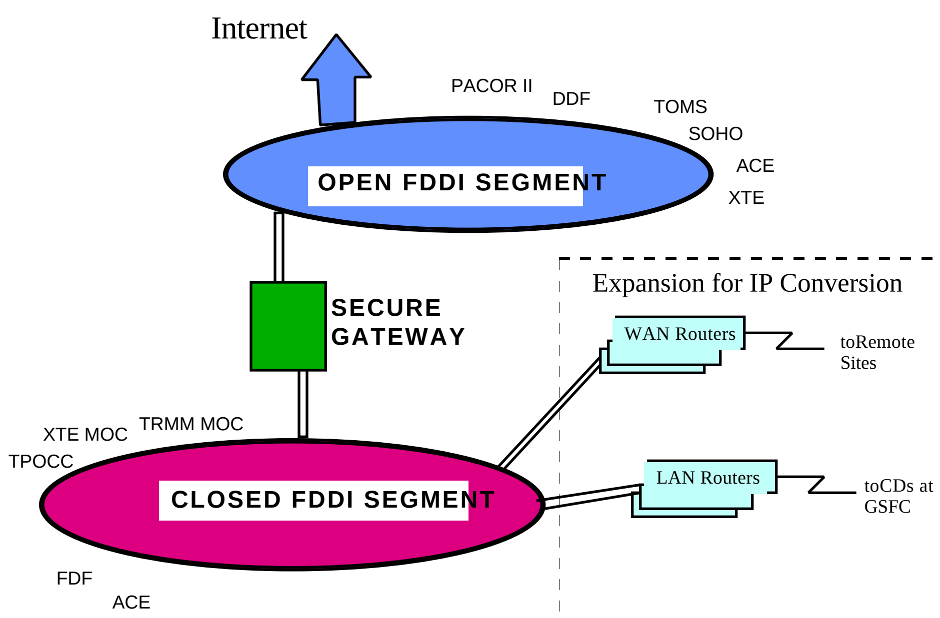


Figure 3.1 High Level IONET Architecture

As illustrated in Figure 3.2, the IONET backbone will consist of the GSFC, JSC and WSC triangle. Other significant and fully redundant links will exist between GSFC and the Jet Propulsion Laboratory (JPL) and between GSFC and Marshall Space Flight Center (MSFC). All other communications to and from other NASA supported sites will utilize tail circuits which will be connected to these main sites. GSFC will remain a main center of communication.

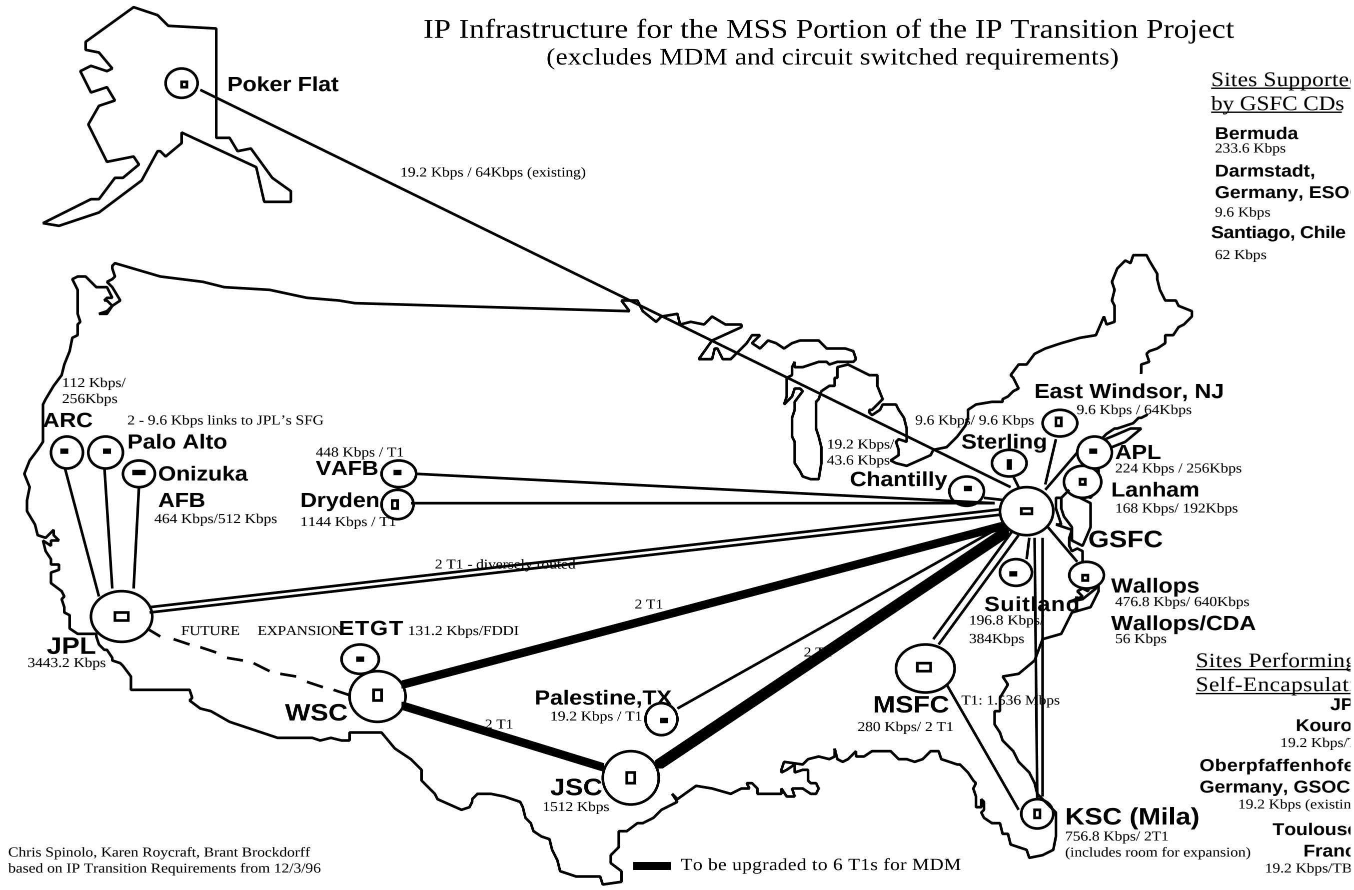


Figure 3.2 Target IONET Backbone

3.1.2 Communication Protocols and Technologies

Ethernet technology and the communication protocols described below are used in IONET.

Ethernet technology is a packet switched LAN technology. The Ethernet is a 10 Mbps broadcast bus technology with best-effort delivery semantics and distributed access control. It is considered a bus technology because all stations share a single communication channel. It is broadcast because all transceivers receive every transmission. Ethernet is called a best-effort delivery mechanism because the hardware provides no information to the sender about whether the packet was delivered. The distributed access scheme is called Carrier Sense Multiple Access with Collision Detect (CSMA/CD). A host can not initiate a transmission if another message is being transmitted. Collisions may occur when hosts start transmissions simultaneously. Ethernet uses a binary exponential backoff policy where a sender delays a random time after the first collision, twice as long if a second attempt to transmit also produces a collision, four times as long after a third failed attempt, and so on. There is no flow control. The IP network does not provide a metered data rate even if a sender transmits data at a constant rate. Bursts of data may arrive at the full Ethernet line rate since the Ethernet is a shared resource subject to collisions (CSMA/CD).

Internet Protocol (IP) is described in RFC 791 (Sept. 1981). The IP RFC formally specifies the format of internet packets, called datagrams, and informally embodies the ideas of connectionless delivery. The Internet Protocol is designed for use in interconected systems of packet-switched computer communication networks. The IP implements two basic functions: addressing and fragmentation. Internet software uses fields in the internet header to fragment and reassemble internet datagrams when necessary. Two key parameters in the internet header are Time to Live and Header Checksum. The Time to Live parameter determines how many hops the datagram is allowed to make before it is destroyed. The Header Checksum provides a verification that the data was transmitted correctly. If the header checksum fails, the internet datagram is discarded at once. Errors detected may be reported via the Internet Control Message Protocol (ICMP).

User Datagram Protocol (UDP) is described in RFC 768 (August 1980). UDP incorporates sender and receiver 16-bit port numbers in each UDP message which extends the IP interface to the application level and provides application programs with the ability to communicate using the unreliable connectionless IP packet delivery service. UDP provides a transport layer service that supports the multicasting protocols which are needed to support the Nascom data flows from a single source to multiple destinations. UDP delivery performance will be maximized through the design of adequate buffers and appropriate sizing of bandwidth throughout the network.

Use of **multicasting** protocols minimizes the bandwidth needed over the backbone as multicast routers transport a single data message to multiple destinations (instead of individual packets being sent to each destination). **Internet Group Management Protocol (IGMP),** RFC 1112 (August 1989), is a user-to-network protocol used by hosts and routers involved in multicasting. IGMP allows a host to join or leave a multicast group. A multicast group is associated with a unique Class D IP address and by joining a multicast group a host is then able to receive data associated with that Class D address. All IP Transition routers and conversion devices will support IGMP allowing full participation in network transport services.

Multicast Open Shortest Path First (MOSPF) protocol was selected as a router protocol based on demonstrated capability to meet requirements for non-flooding, fault isolation and fault recovery. The non-flooding attributes of MOSPF ensure against saturating bandwidth with error recovery messages. Fault isolation ensures that a localized fault does not affect unrelated data flows. Fault recovery is established by re-routing around a circuit or failed network device within 20 seconds. MOSPF must run in a single OSPF domain. IONET, which includes the IP infrastructure as a subnet, is a single domain. The IP infrastructure for the Nascom transition is relatively small in size and depth, ensuring that the processing to calculate the shortest open paths will not become burdensome. MOSPF is a mature protocol and is not expected to have revisions.

Simple Network Management Protocol (SNMP) , RFC 1157 (May 1990), is a standard protocol which will be used by the network management system to monitor and control routers and conversion devices.

Integrated Systems Digital Network (ISDN) dial up technology will provide a means of fault recovery for sites with a single Tail Circuit. It can also be used for obtaining extra bandwidth in times of peak loads on the IONET.

The **Real-time Transport Protocol (RTP)** , RFC 1889 (Jan . 1996) header provides a sequence count which can be used to monitor for missed data or data out of sequence from a single source. The RTP header is embedded within the data portion of the UDP datagram before application data.

3.1.3 Infrastructure Components

The **routers** selected for the IONET expansion are Bay Networks Access Stack Node (ASN), Backbone Link Node (BLN) and Backbone Concentrator Nodes (BCN) routers with MOSPF protocol.

The Bay Networks ASN router is a stackable router architecture providing integration of multiple units stacked together for management as a single router. This provides flexibility in sizing the network architecture for peak performance. Each ASN unit supports up to 15 network interfaces. The ASN supports LAN interfaces (100BASE-T, Ethernet, Token Ring, and FDDI) and WAN interfaces (Synchronous, T1, ISDN BRI, and ISDN PRI). The ASN's Motorola 68040 maintains high forwarding rates even when processing SNMP management inquiries.

The Bay Networks BLN and BCN routers are multiprotocol router/bridges designed to satisfy high performance and availability requirements of mission-critical backbone internetworks. The routers have symmetric multiprocessor architecture using multiple MC68070 and MC68040-based Fast Routing Engines (FRE) and 1 Gbps Parallel Packet Express (PPX(tm)) to deliver high performance and availiability. The range of support goes from over 330,00 packets per second (pps) and 16 LAN/WAN interfaces (up to 4 FDDI) for the BLN to 52 LAN/WAN interfaces (up to 13 FDDI) and system forwarding performance that scales to 1 Mpps for the BCN. Comprehensive hardware and software redundancy options provide complete fault resiliency. LAN connectivity includes Ethernet/802.3, 4- and 16-Mbps Token Ring/802.5, and FDDI. WAN connections are provided through synchronous lines operating from 1200 bps to 52 Mbps, including Fractional T1, T1/E1, and T3. ATM networks can be connected using a SONET/SDH OC-3 interface.

These Bay Networks routers also provide serial interface support that allows use of dial-up ISDN services such as Dial-on-Demand or Bandwidth-on-Demand for WAN recovery scenarios. The MOSPF protocol provides fault isolation and recovery.

The IP implementation will not include filtering or prioritization initially. The infrastructure for GSFC is illustrated in Figure 3.3. The CONC components shown on the diagram are **concentrators**. The concentrators are fiber optic hubs providing alternative connections and enhancement of signals.

3.1.4 Cable/Interface Standard

Fiber optic circuits will be used as the GSFC backbone to minimize bit errors. The common LAN interfaces will be 10 Mbit Ethernet to and from the Conversion Devices. 100 Mbit Ethernet will be used to interface to the modified MDMs. Standard interfaces will be used wherever possible. NSAP II grade circuits will not be available initially. Router capabilities will be used for diverse routing and failover capabilities. ISDN backup will be used in the architectural tail circuits to support failovers and conserve on bandwidth.

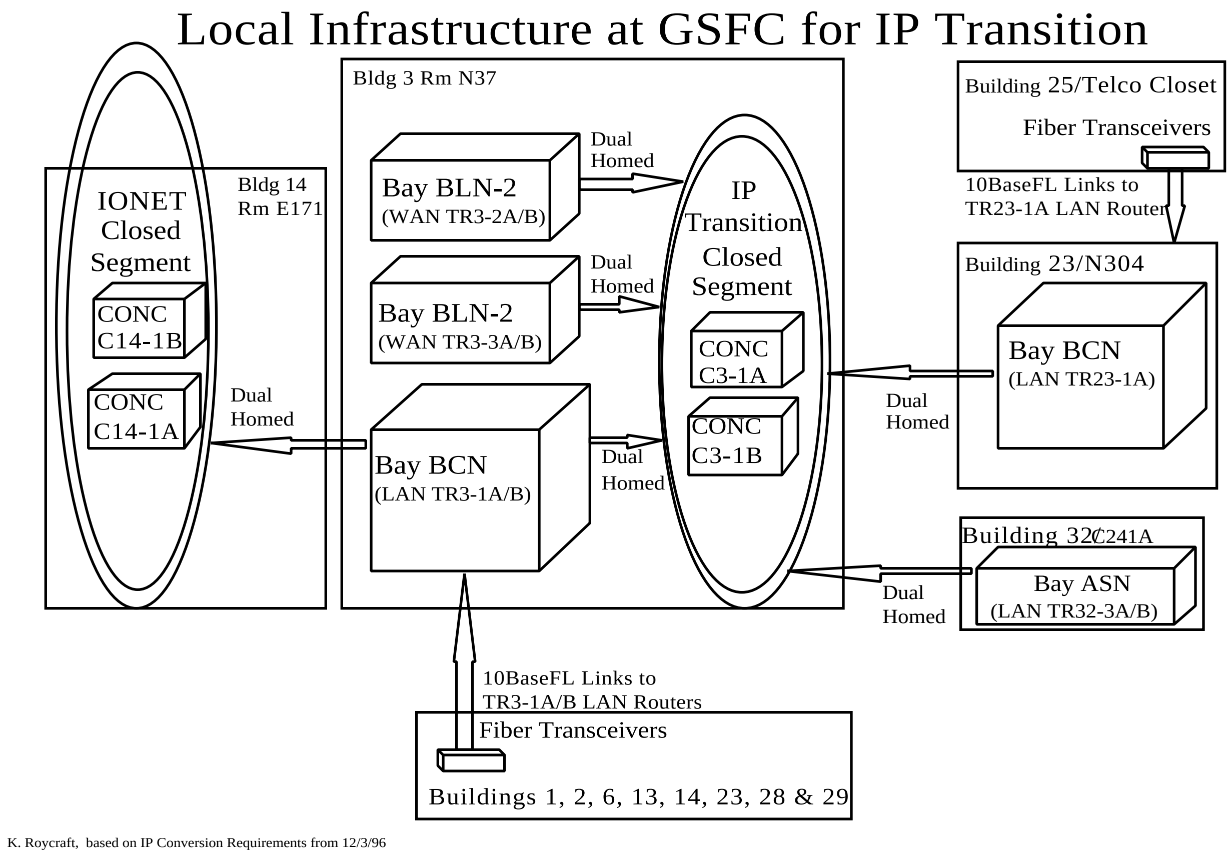


Figure 3.3 GSFC Infrastructure

3.1.5 Conversion Devices

Conversion devices (CD) provide the interfaces between the user serial lines with 4800-bit-block I/O and the IP backbone. This is illustrated in Figure 3.4.

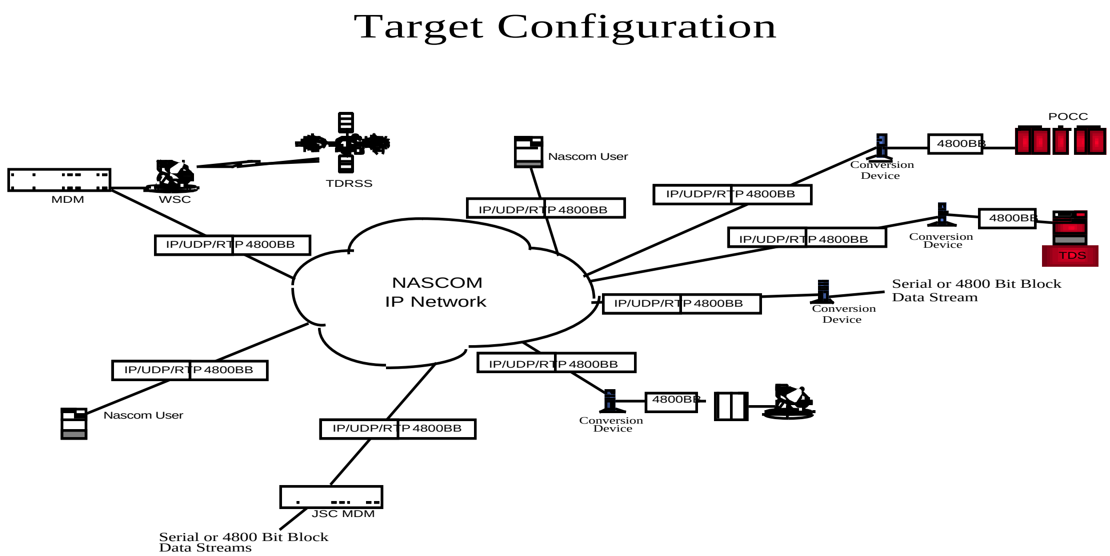


Figure 3.4 Target Configuration

Conversion devices will encapsulate 4800-bit-block data into RTP/UDP/IP datagrams for routing via the IP network. Conversely, conversion devices will de-encapsulate the 4800-bit-block data from the RTP/UDP/IP datagrams and forward the blocks to the serial user. Formats are specified in the *Nascom IP Transition Data Format Document* for encapsulation and routing of data. Nascom conversion devices will be configured and controlled by the NMS through the manipulation of two tables maintained by the NMS. The CD Configuration Table will be unique for each conversion device and contains IP to serial and serial to IP mappings, subscribed multicast groups, and other information necessary to define and configure a CD and its serial interfaces. In addition, to support message switching of data, each conversion device must obtain a copy of the Destination Code Mapping Table from the NMS for use in mapping destination codes to IP addresses and UDP ports for transmission on the IP network. To support circuit switching, data configuration information found in each conversion device's CD Configuration Table will be used to map serial interfaces to IP addresses and UDP ports.

Nascom conversion devices include Small Conversion Devices (SCDs) which use the Nascom Interface Board (NIB), and Programmable Telemetry Processors (PTPs) which use an AVTEC serial board. Both devices will support multicasting protocols and SNMP for network management. The major differences between the SCD and PTP are the number of serial interfaces supported (two for the SCD and five for the PTP) and the ability of the PTP to support unblocked data.

3.1.5.1 Small Conversion Device (SCD)

The SCD is a PC-based (133 MHz Pentium) platform which uses NIB boards for its serial line interface(s). The NIB has an EI-449 connector to receive and transmit 4800-bit-blocks. The SCD also has a 3-Com Ethernet interface board for UDP/IP communications. More detailed specifications are found in Appendix A.

The SCD uses a stable freeware version (v2.0) of Linux operating system software. It supports internal serial clock rates between 4.8 Kbps to 1.544 Mbps and is capable of supporting external clocking. More detailed requirements are found in the *Nascom SCD System Requirements Document (June 1996).*

Functionally, the SCD will:

Encapsulate 4800-bit-blocks into User Datagram Protocol packets for transmission over the IP network

Insert RTP header sequence number by serial interface on encapsulation

De-encapsulate 4800-bit-blocks from the IP network for transmission to the user's equipment

Validate sequence number order and either discard to forward out of sequence block

Provide performance information to a Network Management System (NMS) using Simple Network Management Protocol (SNMP) with an extended MIB II.

Support data rates up to T1 (duplex) on a single 4800-bit-block serial interface

Support a combined aggregate data rate of up to T1 for two 4800-bit-block serial interfaces

Support a maximum of two 4800-bit-block interfaces per system (three in Release 3)

Support a 10 Mbps Ethernet interface

Support Internet Group Management Protocol (IGMP) for multicasting

Generate Circuit Assurance Blocks (CABs) for MDM interfaces

Optionally forward CABs to the user

Map source/destination codes to IP addresses and UDP ports for routing

Map serial interfaces to fixed IP transport address in support of circuit switching

Provide performance and accountability data for each installed 4800-bit-block interface

Provide operator interface for viewing performance and accountability data

Provide administrator interface for configuration modifications

Interface to the Network Management system for routing and configuration information

Provide data metering

3.1.5.2 Programmable Telemetry Processors

The PTP is a PC-based (133 MHz Pentium) platform which uses Avtec boards (up to 4) for its serial line interface(s). The operating system is OS/2 Warp Connect Version 3.0. The PTP also has an Ethernet interface board for UDP/IP communications. It supports internal serial clock rates between 4.8 Kbps to 2.2 Mbps and is capable of supporting external clocking. The PTP supports an aggregate data rate up to 6 MB. With full implementation the PTP will:

Encapsulate 4800-bit-blocks into UDP packets for transmission over the IP network

Insert RTP header sequence number by serial interface for encapsulation

De-encapsulate 4800-bit-blocks from the IP network for transmission to the user's equipment

Validate sequence number order and either discard or forward out of sequence block

Provide performance information to a Network Management System (NMS) using Simple Network Management Protocol (SNMP)

Support data rates up to 2.2 Mbps on a 4800-bit-block interface

Support up to four 4800-bit-block interfaces per system

Support a 10 Mbps Ethernet interface

Support Internet Group Management Protocol (IGMP) for multicasting

Generate Circuit Assurance Blocks (CABs) for MDM interfaces

Optionally forward CABs to the user

Map source/destination codes to IP addresses and UDP port numbers for table driven routing

Map serial interfaces to fixed IP transport address in support of circuit switching

Provide performance and accountability data for each installed 4800 -bit-block interface

Interface to the Network Management system for routing and configuration information

Provide data metering

Support unblocked data

3.1.6 Modified MDMs

The MDM at WSC and JSC will be modified on the aggregate side to interface to the Nascom IP network. They will have increased buffering to reduce gap variance.

The MUX aggregate side will:

Insert RTP header sequence number by serial interface for encapsulation

Encapsulate 4800-bit-blocks into User Datagram Protocol packets for transmission over the IP network (there will not be a redundant stream from a second MUX)

Provide performance information to a Network Management System (NMS) using Simple Network Management Protocol (SNMP)

Support Internet Group Management Protocol (IGMP) for multicasting

Map Logical Port Addresses to IP addresses and UDP port numbers from NMS generated mapping table

Interface to the NMS via SNMP to receive configuration changes

The aggregate output of the MUX will still support the same data rates as they do today, but the data format will change to support the transfer of data over an IP network. The MUX will no longer use the 80 bit link header that is currently added to each 4800-bit-block. The data will be blocked before encapsulation for transmission in the IP network. After receipt by a conversion device(s), the data will be de-encapsulated and optionally deblocked for the user. The PTP conversion device will support deblocking output to the user, but the SCD will not.

The DEMUX aggregate side will:

De-encapsulate 4800-bit-blocks from the IP network for transmission to the user's equipment

Map received data UDP port number to Logical Port Address for OTU transmission using NMS generated mapping table

Validate sequence number order and forward out of sequence block

Validate source IP address

Provide performance information to a Network Management System (NMS) using Simple Network Management Protocol (SNMP)

Interface to the NMS via SNMP to receive configuration changes

3.2 Basic Data Transport Scenarios

The use of IP multicasting will be supported in conversion devices, modified MDMs and routers. Conversion device routing will support both message switching and circuit switching functionality. MDM routing will support the circuit switching functionality.

3.2.1 IP Multicasting

IP multicasting provides a technique for multipoint routing. and will be used in IONET. Multipoint routing is a requirement inherent in the current MSS and the Nascom MDM/DMS interface. In IP multicasting, an individual multicast group is a group of hosts that have all subscribed to receive data from an application. The IP packet containing the data can be identified by a particular Class D IP address and the subscribing hosts “join” that multicast group (NOTE: Operationally this will be done by users via voice request to the COMMGR). Each host wishing to receive data identified by that Class D IP address must be registered as a member of that multicast group. The software involved in establishing these groups must incorporate the Internet Group Mangement Protocol (IGMP), a message interface between hosts and routers. In IONET, the hosts will be the conversion devices and the modified MDMs. IONET routers will keep track of these groups dynamically and build distribution "trees" that chart paths from each sender to all receivers and forwards data to those hosts. As a router receives traffic for the multicast group, it refers to the specific tree that it has built for the sender. Routers in IONET will be using MOSPF as the protocol that will be used to build the distribution trees for multipoint routing.

3.2.2 Conversion Device Data Routing

3.2.2.1 Table Driven Routing

The conversion devices will support message switching by table driven routing. The 4800-bit-block Destination Code Mapping Table will associate established Nascom destination codes to Class D multicast addresses. The conversion devices' configuration will define a serial interface as table driven based on the circuit being supported. For 4800 bit-block messages destined to IONET from the user system, the conversion device will extract the Class D multicast destination address and port number (this combination is termed the "transport address") from the Destination Code Mapping Table based on the destination code contained in the Nascom header of each 4800-bit-block message. The 4800-bit-block will be encapsulated in a RTP/UDP/IP datagram and forwarded for IP transmission using the extracted transport address. The receiving conversion device(s) will be configured to listen for data on that Class D multicast address and direct the data to one of its serial interfaces. More than one conversion device may be listening to the same Class D address and a single conversion device may listen to more than one Class D address.

The listening conversion device(s) will read the message from the network, de-encapsulate the message (removing the RTP/UDP/IP headers) and forward the 4800-bit-block at the configured data rate to the appropriate serial interface based on the multicast address/UDP port. The RTP sequence number can be used to determine if blocks are missing or out of sequence. The users will have the option to receive or discard blocks received out of sequence based on the setting of the applicable conversion device configuration parameter.

3.2.2.2 Fixed Routing

The conversion devices will support circuit switching by fixed routing. That is, a serial interface will be mapped directly to a Class B unicast address for special case point-to-point communications or to a Class D multicast address for point-to-many and point-to-point communications. This form of routing will be established through the NMS configuration of the Conversion Devices and can be established for each or any serial interface. Fixed routing will support the capabilities provided by the current MDM interface and for circuit switching done currently for playbacks, testing, emergencies, or 'make good' situations. Some of this current switching is done through the DMS and patch panel.

The conversion device will read a 4800-bit-block of user data from a serial line that is configured for fixed routing. The data will be encapsulated into a RTP/UDP/IP datagram and sent to the fixed transport address found in the configuration table for the input serial line. Listening conversion devices(s) and/or modified MDMs which have joined the fixed Class D multicast address will read the message from IONET. The receiver may be another conversion device or a modified DEMUX at WSC or JSC. The message will be de-encapsulated, removing the RTP/UDP/IP headers, and the extracted 4800-bit-block is forwarded at the configured data rate to the appropriate serial interface based on the IP address/UDP port.

SN scheduled services are an example of fixed routing and include forward and return services between TDRSS and users via WSC MDMs.

Forward data service is defined as data originating from users to the TDRSS via WSC DEMUX. Data will be transmitted from a user on a serial line to a conversion device. The conversion device will be configured to map to the fixed DEMUX IP transport address at WSC. The conversion device will encapsulate the data and will send it to the WSC DEMUX using the Class D IP address and UDP port number specified for the WSC DEMUX in the CD

Configuration Table. At the modified DEMUX, the data will be received and the source IP address checked to verify that the originator is authorized to send to that port address. The received UDP port number will be mapped to a Logical Port Address in the DEMUX mapping table. The data will be de-encapsulated and routed to the OTU corresponding to the Logical Port Address. The sending conversion device must insert CAB blocks whenever necessary to ensure that the OTU receives a block at least once a second while the OTU is enabled at WSC.

Return data service is defined as data originating from TDRSS via the WSC MUX to users in the network. TDRSS data is sent to the MUX ITU when scheduled for output on the associated Logical Port Address. On the modified aggregate side, the Logical Port Address will be used to look up a Class D multicast address and UDP port for the data in the MUX mapping table. The data will be blocked, encapsulated and transmitted using the Class D IP address via UDP/IP. All Conversion Devices listening to the specified multicast group will receive a copy of the block, de-encapsulate it and route it to the designated serial line based on its Class D IP address and UDP port. CAB blocks from the MUX can be forwarded or dropped at user option depending on the setting of the applicable parameter in the CD Configuration Table.

3.3 Other Data Transport Services

In IONET, the NMS will be integral to supporting other data transport scenarios including SN playback, testing, and network emergencies and failure recovery.

3.3.1 SN Playback Services

Additional Logical Port Addresses will be reserved in IONET for SN playback. These addresses will allow unique logical port addresses for playback per user. Users will have two entries in the WSC MDM MUX table one for operational data, the other for playback. Users who use the same circuits for real time return link data and playback data will co-ordinate playback activities and configuration changes with the COMMGR. A change must be made in the user configuration table to listen to the multicast address and UDP port associated with the playback data The NCC will continue to direct coordination with WSC, which records the data on tape. Users who have dedicated circuits for playback will require no change to their conversion device configuration. [The same Class D address may or may not be used for playback.]

3.3.2 Testing Services

Unique Class D multicast addresses will be allocated for network testing. Fixed routing will be used to emulate circuit switching. Again, coordination must occur with the COMMGR to initiate configuration changes in the supporting conversion device(s) at the start and end of testing. For fixed routing, the sender’s conversion device serial interface fixed route will be set to the test Class D multicast address. The receiving conversion devices’ changes will be in the form of modifying listening groups per serial interfaces.

3.3.3 Emergencies/ Make Goods Scenarios

For emergency or make good situations, the COMMGR will be notified and will direct changes via the NMS to mapping tables or configuration tables associated with the MDMs and/or conversion devices to use backup circuits where available.

Each user will have available a backup conversion device for configuration should a conversion device fail. Operator intervention will be required to redirect circuits or serial interfaces from the failed device to the backup device.

Coordination with the COMMGR will identify the appropriate device configuration. Configuration changes to the device will prompt the appropriate interchange with the router to resume data flow through the new path. No change need be made at WSC or to any other sending/receiving conversion device.

3.4 Nascom Configuration Management Services

This section provides an overview of Nascom configuration management services used for the IP transition devices. Topics include IP address management, definition of NOC NMS functionality supporting IP transition, conversion device data management and SNMP monitoring and control.

3.4.1 IP Address Management

Nascom controls and administers both the Class B and Class D addresses used in IP transition portion of IONET. Class B addresses are assigned to the hardware entities on the network. Class D addresses are used to define the data flows and reception functionality's supported under IP multicasting.

Users currently identified and operational within the 4800-bit-block network transition to IONET according to a schedule developed through coordination between each user site and Nascom's site installation teams. Future users identify themselves and their requirements through the Nascom IONET User Connection Application process established initially for MODNET-NOLAN.

Nascom assigns a Class B unicast IP address to Nascom-provided conversion devices and to users wishing to have a conversion device host on IONET. This address will be used by the NMS, conversion devices, and other encapsulation/decapsulation hosts to send unicast IP communications such as mapping and configuration table changes and SNMP messages, if applicable.

Class D addresses will be assigned according to the following scheme:

Start Address	End Address	# Reserved	IONET Function
225.0.0.0	225.0.0.255	256	Destination Code Mappings (Permanent)
225.0.1.0	225.0.1.255	256	Destination Code Mappings (Temporary for MSS transition)
225.1.0.0	225.1.15.255	4096	Return Link Services (Operational)
225.2.0.0	225.2.0.15	16	Forward Link Services (Operational)
225.3.0.0	225.3.15.255	4096	Manual patch and circuit switch
225.4.0.0	225.4.15.255	4096	Test

3.4.2 Network Management Interface

Nascom's Network Management System (NMS) will be located at Nascom's Network Operations Center (NOC). It will be manned 24 hours a day and 7 days a week to service IONET users. The user's contact with the NMS will continue to be through the COMMGR. The NMS is supported with HP OpenView and will functionally consist of:

A repository of data to define the Destination Code Mapping Table, the configuration table of each operational conversion device, and the MDM MUX and DEMUX mapping tables

A mechanism to monitor and report on the connectivity, configuration and performance of each entity within the network

A NOC operator interface to modify the repository of data

The capability to download mapping and configuration information to conversion devices

A telnet capability to access and login into Nascom provided conversion devices to support configuration changes when necessary.

An ftp server to support configuration changes when necessary.

The capability to configure modified MDMs and change MDM mapping information via SNMP.

3.4.3 NMS Management of Configuration and Mapping Tables

The Network Management System will have the capability to manage the data associated with the Destination Code Mapping Table, the CD Configuration Tables, and the MDM MUX and DEMUX mapping tables. Formats for these tables are defined in the *Nascom IP Transition Data Format Document*.

3.4.3.1 Destination Code Mapping Table

The Destination Code Mapping Table maps 4800-bit-block destination codes to an IP address and UDP port. The NMS will maintain and manage the master copy of this table. This table will be transferred to any conversion device via initiation by the NMS as a result of changes made to the master copy or by request issued by a conversion device.

Upon initialization, the conversion device will interface with the NMS to obtain the Destination Code Mapping Table updates. The NMS will use an SNMP trap to notify CDs of changes to be downloaded. The CD responds to messages from the NMS of applicable table changes by contacting the NMS server and downloading (via ftp) the appropriate table information from the NMS.

3.4.3.2 CD Configuration Tables

There will be a CD Configuration Table maintained in the NMS repository for each conversion device. Each table contains IP to serial and serial to IP mappings for fixed routing services, subscribed multicast groups, and other information necessary to configure a CD and its serial interfaces. Upon initialization, the conversion device will interface with the NMS to obtain configuration updates. The NMS will use an SNMP trap to notify CDs of configuration changes to be downloaded. The CD responds to messages from the NMS of applicable table changes by contacting the NMS server and downloading (via ftp) the appropriate table information from the NMS.

The SNMP capability to trigger download of CD Configuration Tables will not be implemented initially by the NMS. Until the NMS incorporates this feature, CD configuration changes will, however, still be handled remotedly by an authorized operator either via telnet sessions to SCDs or via remote utility update of PTPs by NMS operators. The PTPs employ a windows based user interface which cannot support remote logins via telnet. An operator at the NMS under the direction of the COMMGR and in accordance with NOC operating procedures will have the capability to login directly to Nascom SCDs to view current information and make changes directly, if necessary. Changes to the SCD’s configuration will be allowed only from the SCD system administrator account, the password of which will be available only to the operator at the NMS.

3.4.3.3 MDM Mapping Tables

The MUX mapping table maps the LPA of a MUX ITU to an IP address and UDP port. The DEMUX table maps the receiving UDP port of the DEMUX to the logical port address of a DEMUX OTU and contains the source IP addresses and subnet mask of the user hosts which are authorized to send to that OTU. Although these tables are resident in the modified WSC and JSC MUXs and DEMUXs, respectively, the master is maintained by the NMS. SNMP is used to make changes to the version maintained in the MUX and DEMUX.

3.4.4 Network Monitoring and SNMP Management Overview

Nascom will provide SNMP network management via HP OpenView for IP transition devices (conversion devices and routers) including fault monitoring, fault isolation and restoral of services. The network is monitored every 5 minutes using SNMP and ping utility.

The CDs will support SNMPv1 in order to be managed by the NMS. With Management Information Base-II (MIB-II) support, additional information will be available about message traffic.

The CDs will have a proprietary extension to the MIB II allowing interaction with NMS for the update of configuration and mapping tables and additional exchange of information. When implemented, table control communications will be initiated through SNMP. Upon notification from the NMS, the CD will download the Destination Code Mapping table from the NMS server. The CD will be capable of sending unsolicited state information, configuration changes, and error conditions asynchronously to the NMS (TRAPS).

The modified MDMs will have a proprietary extension to the MIB II allowing interaction with NMS for the update of configuration and mapping tables and additional exchange of information. Configuration changes and mapping table changes will be provided to the MDMs from the NMS via SNMP. The MDMs will be capable of sending unsolicited state information, configuration changes, and error conditions asynchronously to the NMS (TRAPS). In the modified MDMs, the IP stream can be stopped at the modified circuit card by an SNMP command.

3.4.5 Engineering and Maintenance Responsibilities

Continuing engineering and network monitoring services are provided by Code 540 to support IP Transition users.

The Nascom Communications Manager (COMMGR) coordinates all troubleshooting and maintenance activity. The COMMGR can be reach at (301) 286-6141 and will notify the appropriate personnel. The user may expect a return call within 2 hours regarding the problem.

Network monitoring of IP Transition hardware devices is provided via HP OpenView software on a 24 hour basis. The Nascom conversion devices are included in the monitoring scope of the IONET Closed Segment being monitored in the Nascom Technical Control area. Devices are polled for status every 5 minutes via SNMP or ping.

Remote users and GSFC projects are responsible for the maintenance of the Nascom CD hardware which are COTS Pentium personal computers.

The FTS2000 contractor, currently AT&T, is reponsible for maintaining the WAN routers at remote sites and at GSFC.

Conversion Device software maintenance will be provided by Nascom, including application software and operating system software. The procedures for software updates are described in the Installation and Troubleshooting Guides.

Logistics support is provided for the CD serial interface boards to insure a supply is available for failure scenarios.

Nascom configuration control is required for all new installations, upgrades, or permanent reconfigurations. This involves the Engineering Change process, which involves documentation and approval of changes to hardware and software associated with Nascom.

Users utilizing IONET are required to document the networks they are responsible for that connect to the network and provide that information to the IONET Project Manager.

3.4.6 Circuit Failover Scenario

Many users will have a set of primary circuits that are permanently supported by operational CD(s), and one or more "spare circuits" that are also permanently supported by operational CD(s). For failover from a primary circuit to a "spare circuit", under normal circumstances, the user would follow the same procedures as they do currently in conjunction with Nascom Operations to quickly change an operational data flow from a non-functional primary circuit to a spare circuit; no physical connectivity changes at the CD rack would be required for this. Nascom's procedure, in conjunction with the user site, for correcting an non-functional primary circuit circumstance might be 1) to switch the data flow from the primary circuit to a spare circuit, 2) to determine the cause of the primary circuit problem, and 3) if the cause is a CD, to failover from the problematic operational CD to a spare CD.

3.4.7 Conversion Device Failover Scenario

Each site will have a spare conversion device installed. It will be connected to IONET at all times. Human intervention at the site and NMS operator intervention must occur to make this spare device fully operational. In coordination with the COMMGR/NMS operator, the site operator will be responsible for any patching required to move the serial circuit interface connections from the failed CD to the backup CD. In most cases, an I/O panel will be installed, facilitating the switching of serial cables from the primary CD ports to the ports for the spare. At the same time, the operator at the NMS will be responsible for ensuring that all appropriate CD Configuration Table modifications are done such that service can be restored for those circuits on the backup CD. It is assumed that the NMS has the current configuration of the failed CD either in a data repository or on a floppy disk in the conversion device. No physical connectivity changes are required for the Ethernet connections of the CDs. Procedures for effecting failovers will be provided during installation.

3.4.8 Transition to Common Carrier Support

At a time still being negotiated, a significant portion of network management support will move to common carrier responsibility.

4. Transition Operations

The *Nascom IP Transition Project Transition Plan* documents the implementation steps for the transition from Nascom's 4800 bit-block infrastructure, which uses the MSS, MDMs and DOMSAT, to the IP infrastructure. This section will discuss the operational concepts associated with these steps: First, MSS services will be converted to IP. This will be followed by the transition of the the MDM services which, in turn, will be followed by the transition of the remaining point-to-point services.

4.1 MSS Transition to IP

This section discusses the MSS IP Transition architecture and operations leading to the removal of MSS.

4.1.1 MSS Transition Architecture

User sites transition to IONET on a staggered schedule from August, 1996 to January, 1997. Dual circuits will be provided for data to reach each user site via the existing circuit and the IONET circuit. This will provide a fallback during installation, configuration, and the period prior to cutover. One path will carry IP data and the other will carry serial clock and data. A switch will be provided for cutover, if necessary.

The MSS will have a conversion device gateway to the IP backbone to allow IONET transitioned users to communicate with users not yet transitioned. This is illustrated in Figure 4.1. The bandwidth requirements necessary to support the MSS transition will be balanced among the four operational MSS front end SCDs.

4.1.2 MSS Transition Operations

During the phased MSS transition, user CDs will be installed gradually on a site by site basis. The COMMGR will be responsible for managing and directing all configuration changes required for Nascom operational and test support on both the MSS and user CDs during the period when MSS and IP infrastructure components co-exist. Users requesting MSS support for tests will continue to follow current procedures including the use of Briefing Messages to the NCC or directly to the COMMGR. Briefing Messages should contain: time and duration of test, participants, objective, data rate, type of data, circuit, destination codes and the relationship between the destination codes and the circuits.

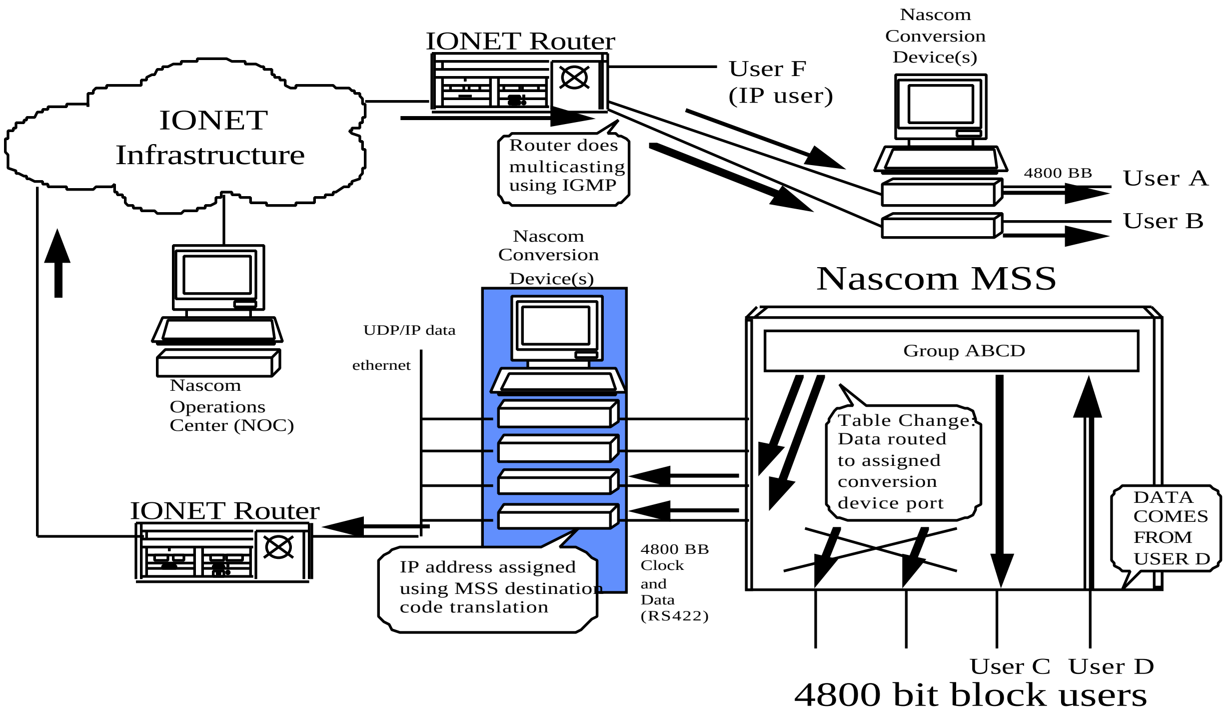


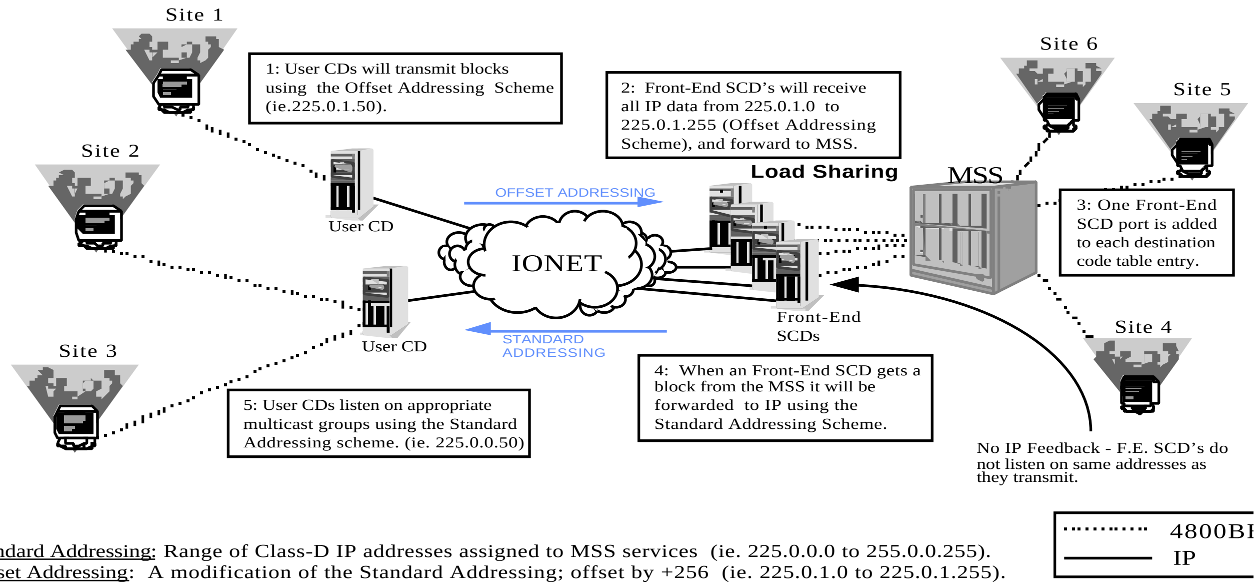
Figure 4.1 MSS Conversion Device Gateway

For the initial MSS front end installations and for subsequent site installation tests the COMMGR will be provided all necessary configuration and procedural information from the designated Test Coordinator at least 72 hours prior to a scheduled installation. The Test Coordinator will communicate with both site installation teams and the COMMGR to ensure that all necessary information is provided. Such information includes CD configuration parameters such as data rates, host IP address (Class B), listening groups (Class D), etc., and also the MSS port changes necessary to modify the routing on the MSS from the dedicated serial port to one of the front end SCD ports. The Test Coordinator will be on-site at GSFC to assist the COMMGR during all installations until it can be agreed that a 24-hour on-call support policy will be sufficient. Common changes to routing will have to be coordinated between the MSS operations and the NMS configuration control of CDs. When updates to the Destination Code Mapping Table are necessary they will be managed by the NMS as directed by the COMMGR.

4.1.3 Destination Code Mapping Tables During Transition

A duplicate packet scenario has been identified related to the co-existing infrastructures which requires that all IP traffic must initially be directed to the front end SCDs. Refer to Figure 4.2. The front end SCDs will be configured to listen to all active destination code multicast addresses.

Solution to IP Transition Echo



Standard Addressing: Range of Class-D IP addresses assigned to MSS services (ie. 225.0.0.0 to 255.0.0.255).
Offset Addressing: A modification of the Standard Addressing; offset by +256 (ie. 225.0.1.0 to 225.0.1.255).

Advantages: - Solves both MSS Echo problem and Multicast Feedback through Front-End SCD's.
- MSS remains the hub of communications until its removal.
- Once all users have transitioned, User CDs are sent updated MSS tables which tells them to transmit using the Standard Addressing scheme. All traffic traverses the IP connection only and thus bypasses MSS and the Front-End SCDs. Front-End SCDs are unplugged. (Easy Transition).

Figure 4.2 Initial IP Transition MSS Configuration

[NOTE: This will also require two Destination Code Mapping Tables: one for the front end SCDs and one distributed to all other IP user CDs. The latter table will employ IP address offsets that only the front end SCDs will be listening to and will ultimately be phased out by the end of the MSS transition so that only the Destination Code Mapping Table used by the front end SCDs will remain.] The front end will forward de-encapsulated 4800-bit serial blocks to the MSS and the MSS, in turn, will route the blocks to its serial ports according to its own internal destination code table. When a user port is cutover to an IP conversion device, MSS routing tables will add a front end conversion device port to that port on the MSS. In this scheme, data that needs to reach users already transitioned to IP will be routed back out of the MSS to one of the front end SCDs which will encapsulate the data and transmit it to the network using the appropriate Class D address. Gradually, as more users transition to IP, the MSS will be internally mapping more data to the SCD ports for IP transmissions instead of the ports previously dedicated for serial transmission to the user sites. When no user still connected to the MSS needs to send to or receive from a given destination code, that code can be removed from the MSS's table. The user's Destination Code Mapping Table can be modified so that IP users communicate directly via multicasting (i.e. the destination code/IP address would no longer use the offset mapping) without the MSS playing a role in reflecting the blocks back out to the IONET.

During this period non-transitioned users will still be able to route to other non-transitioned users as well as to transitioned users already behind conversion devices (For example, serial user X wants to send data to destination code (CD) 150 which is received by JSC-3 and MIL-4, and MIL-4 has transitioned to IP but JSC-3 has not. In this case, the data would go to the MSS which is configured to a port for JSC-3 on current serial lines and also to another port for a conversion device configured to look up a multicast group for DC 150 for IP transmission).

4.1.4 MSS User CD Installation Agenda

Interface testing will verify routing between users still connected to MSS and newly transitioned users and between newly transitioned users and users who are already on IONET.

After site installation testing is completed, user acceptance testing will begin for verification of routing, latency, error rate checks on data.

After an operational checkout period of no more than 30 days, the legacy 4800 bit-block interface will be removed.

When all MSS users have transitioned off of the MSS and have successfully completed acceptance testing, the MSS and the front end SCDs supporting the MSS will be turned down and removed.

4.2 MDM Transition to IP

Figure 4.3 illustrates the transition architecture at a point when the MSS may still be in place, the IP infrastructure has been installed, and redundant services have been established at user sites with installed conversion devices. The main features illustrated include:

a) the coexistence of the Nascom IP Network cloud and the Common Carrier Broadcast Data Transmission System (CCBTS) DOMSAT links between the GSFC, WSC and JSC sites

b) the deployment of conversion devices between serial 4800-bit data and the IP backbone, both between users and TDRSS and between users and other users.

For more information on the MDM transition phase refer to the *Nascom IP Transition Project Transition Plan (July 1996).*

MUXs will be capable of outputting both UDP/IP and 4880-bit-blocks simultaneously during transition testing. DEMUXs, however, will be designed to receive either IP packets or 4880-bit-blocks but not both concurrently. Another limitation during transition will be that a channel by channel transition will not be possible from CCBTS service over to IP. However, WSC will support independent testing with MDM users who are prepared for transition to IP.

The MDMs at JSC will be modified for IP similarly to the modifications being done for the WSC MDMs and thus will provide the conversion to serial lines needed for JSC users, virtually eliminating the need for PC-based CDs. The JSC MACS will remain to support the JSC MDMs but will no longer be commanded by the CSS.

At the conclusion of all acceptance testing all MDM services will be cut over from the CCBTS to IONET. The MDMs at GSFC and MSFC will be turned down and removed as will the CSS, MACS, DCS, and the DMS at GSFC unless there are other patched services that will still need to be transitioned or moved to other equipment in Tech Control.

Transition Configuration

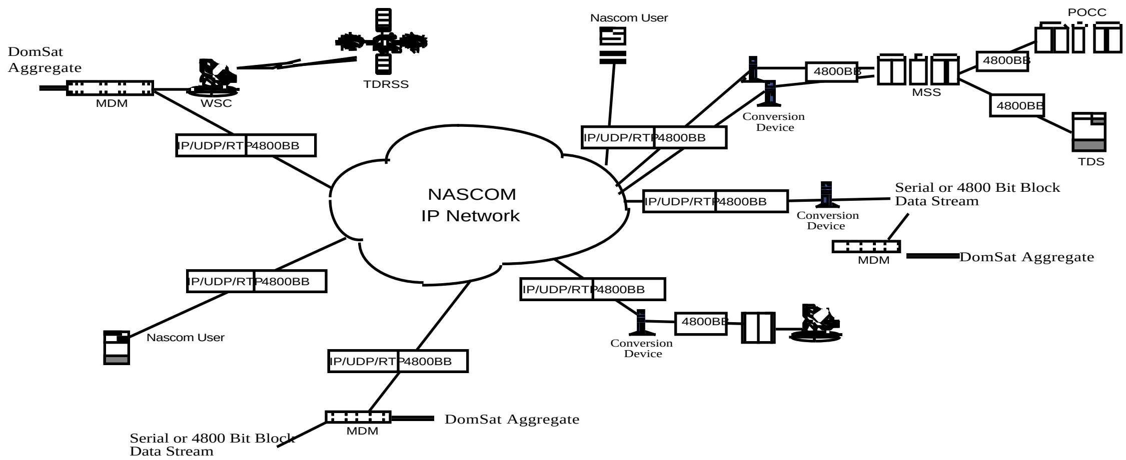


Figure 4.3 Transition Configuration

4.3 Network Management for Initial Transition Without SNMP

During both the MSS and MDM transition period, users will continue to coordinate communication services through the COMMGR. A full Network Management System will not be available during MSS transition. Similarly, the SNMP agent associated with the CDs will not be available until well into the MSS transition.

4.3.1 Network Management System

The network will be monitored 24 hours a day, 7 days a week under control of the NOC. HP OpenView will be available for monitoring functions only. In addition, a server will exist at the NOC that will make available for display destination code/IP multicast address mappings and MSS mnemonic/CD IP address mappings. The operator at the NOC will use the Telnet/system administrator login capability to view or change configuration parameters for all connected SCDs. The NOC operator will direct and assist PTP users to make any necessary configuration changes from the PTP's local operator interface. The NMS will be able to obtain status of critical events on the CDs and inform CDs of Destination Code Mapping Table updates via non-SNMP message protocols employed during the transition period by the NMS and the CDs.

4.3.2 Conversion Devices During Transition

If an FTP server can be found, the SCDs will download mapping and configuration information on startup. Although the capability may not be initially available through the NMS to download configuration information, the conversion devices will have the capability to retain current mapping and configuration information locally to use if the conversion device must be restarted. The CDs will inform the NMS of critical events and respond to Destination Code Mapping Table update messages from the NMS via non-SNMP message protocols employed during the transition period by the NMS and the CDs.

Abbreviations and Acronyms

ADPE	automated data processing equipment
APL	Applied Physics Laboratory
ARP	Address Resolution Protocol
ASCII	American Standard Code for Information Interchange
ASN	Access Stack Node
ATM	Asynchronous Transfer Mode
BCN	Backbone Concentrator Node
BDS	Baseline Data System
BLN	Backbone Link Node
BRI	basic rate interface
CAB	circuit assurance block
CCB	confiuration control board
CCBTS	Common Carrier Broadcast Data Transmission System
CCR	confiuration chnage request
CD	conversion device
COMMGR	Nascom Communications Manager
COTS	commercial off-the-shelf
CSS	Control and Status System
CSMA/CD	Carrier Sense Multiple Access with Collision Detect
CSR	Communication Service Request
DC	destination code
DCF	data capture facility
DCN	document change notice
DEMUX	demultiplexor
DMR	Detailed Mission Requirements
DMS	Digital Matrix Switch
DNS	Domain Name Service
DOMSAT	Domestic Satellite
EC	engineering change
EIA	Electronics Industry Association
EIDE	Enhanced Integrated Drive Electronics
ETGT	Extended TDRSS Ground Terminal
FDF	Flight Dynamics Facility
FTP	File Transfer Protocol
GAM	General Administrative Message
GN	Ground Network
GSFC	Goddard Space Flight Center
HST	Hubble Space Telescope
ICD	Interface Control Document
ICMP	Internet Control Message Protocol
IGMP	Internet Group Multicast Protocol
IONET	Nascom IP Operational Network
IP	Internet Protocol
ISA	Industry Standard Architecture
ISDN	Integrated Systems Digital Network
ITU	Input Terminal Unit
JSC	Johnson Space Center

Kbps	kilobits per second
LAN	local area network
LPA	logical port address
Mbps	megabits per second
MDM	Multiplexer/Demultiplexer
MIB	management information base
MO&DSD	Mission Operations and Data Systems Directorate
MODNET	MO&DSD LAN
MOSPF	Multicast Open Shortest Route First
MSFC	Marshal Space Flight Center
MSS	Message Switching System
MTTR	mean-time-to-repair
MUX	multiplexor
NOC	Network Operations Center
NOLAN	Nascom Operational LAN
Nascom	NASA Communications
NASCOP	Nascom Operating Procedures
NCC	Network Control Center
NIB	Nascom Interface Board
NMS	network management system
NTP	Network Time Protocol
OS	operating system
OTU	Output Terminal Unit
PA	performance analyst
PC	personal computer
PMS	Performance Monitoring System
POCC	project operations control center
PRI	primary rate interface
PTP	Programmable Telemetry Processor
QA	quality assurance
RAM	Random Access Memory
RARP	Reverse Address Resolution Protocol
RFC	Request For Comments
RTP	Real-time Transport Protocol
SAMS	Support and Maintenance Systems
SCD	Small Conversion Device
SN	Space Network
SNMP	Simple Network Management Protocol
SOC	Simulation Operations Center
SONET	Synchronous Optical Network
STS	Space Transportation System
TCP	Transmission Control Protocol
TDRSS	Tracking and Data Relay Satellite System
TDS	Tracking Data System
UDP	User Datagram Protocol
VEST	Vehicle Electrical System Test
WSC	White Sands Complex